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Viral-templated Palladium Nanocatalysts for Dichromate Reduction

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We demonstrate a viral template-based bottom-up assembly approach for palladium (Pd) nanocatalyst synthesis for dichromate reduction. Specifically, genetically displayed cysteine residues on each coat protein of Tobacco Mosaic Virus (TMV) templates provide precisely spaced thiol functionalities for tunable surface assembly and Pd nanoparticle formation. Reaction kinetics studies by *in situ* UV-VIS monitoring reveal catalytic activity of Pd nanoparticle preferentially formed on TMV. In-depth characterization via atomic force microscopy, grazing-incidence small-angle x-ray scattering, and x-ray photoelectron spectroscopy show preferential Pd nanoparticle formation on TMV, stability, and nanoparticle size that correlate well with the reaction kinetics results. We further present two facile routes to control Pd nanocatalyst surface loading based on tunable and selective surface assembly of TMV. In the first method, the surface density of Pd-TMV complexes and dichromate conversion rate are controlled by varying the concentration of TMV solution for surface assembly. In the second method, the Pd catalyst loading and reaction rate are controlled by varying the gold surface area on patterned silicon chips via standard photolithography. We envision that our approach for readily controllable surface assembly of catalytically active Pd nanoparticles under mild aqueous conditions would provide a facile route to catalyst synthesis in a wide range of applications.